Euphorbia esula
Leafy Spurge

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History

The invasive plant *Euphorbia esula*, more commonly known as leafy spurge, has been in the United States since 1827 when its presence was first recorded in Massachusetts, likely arriving in the ballast water of ships. Native to Eurasia, reports indicate that leafy spurge was first noticed in large quantities in south-central Canada and western states such as North Dakota, Idaho and Washington in the early 1900s, likely carried there by homesteaders. It is disputed whether the plant spread throughout North America from Massachusetts or if its presence in the west was the result of an independent introduction in the Midwest, potentially into Minnesota with oats from Russia. While information about the specific timeframe in which leafy spurge arrived in Colorado is limited, a study conducted in Rocky Mountain National Park (ROMO) by Pritekel et al on invasive species notes that ROMO has fought leafy spurge since the mid-1960s. Additionally, a 1987 report documenting 27 Years of Exotic Plant Control in Rocky Mountain National Park notes that "leafy spurge was the first plant in Rocky Mountain National Park to warrant a planned control effort." ROMO's biological concerns and management of the species have much in common with North Dakota's Teddy Roosevelt National Park (TERO) and the land surrounding Wyoming's Devil Tower National Monument. ROMO Exotics Year-End Reports from 2000 to 2013 note study of TERO's management approach as that park deals with high percentages of leafy spurge. The Year-End Reports (YER) and the 2003 ROMO Invasive Exotic Plant Management Plan list leafy spurge as a high priority species for treatment and note prior approval to release insects as a biological control method. Table 1 shows the number of acre of leafy spurge that have been treated with herbicide since 2003 when herbicide use was first approved in the park. In Colorado leafy spurge is listed as a List B noxious weed.[1]

Figure 1. Leafy spurge. Source: William M. Ciesla, Forest Health Management International, Bugwood.org. Available from: Invasive.org, http://www.invasive.org/browse/detail.cfm?imgnum=3943076#sthash.CkmxU7M7.dpuf (accessed August 2014).

Biological Concerns

The biology of leafy spurge causes its management to be quite challenging. The plant is highly competitive due to its allelopathic properties, a deep rhizomatous root system, aggressive seeding, and the ability to tolerate a range of environmental conditions. A study by D.A. Steenhagen and R. L. Zimdahl showed that leafy spurge roots and decomposing litter inhibited growth in surrounding vegetation. Leafy spurge has an extensive root system- spreading 15 to 30 feet below the soil surface- causing manual treatments such as hand pulling to exacerbate its sprawling tendencies. While the ability to regenerate through root shoots should be a concern to those managing this plant, other biological aspects of concern are that leafy spurge can shoot its seeds up to five meters. Seeds left in the ground that do not germinate in late-April or May will remain viable for up to eight years. Adding to the potential spread of the seeds is that each flowering shoot holds an average of 140 seeds. Seeds can thrive in a wide variety of habitats from riparian areas to dry, mountains and rangelands and have the ability to survive and float in water. Due to this environmental variability, methods of spread for the seeds of leafy spurge additionally increase. Vehicles, other road

equipment or hikers as well as rangeland animals that come in contact with the expelled seed all exacerbate its spread. Though animals can play a role in the distribution of leafy spurge seed, not all animals gravitate toward the plant. Cattle in particular do not fare well with the milky sap that lives within the stalk of the plant, as ingesting the latex can cause diarrhea, general weakness or even death. Horses suffer similar effects, though reports focus more on the external ailments such as blisters or hair loss that affect horses in particular. In general, because leafy spurge takes over rangelands and reduces the number of native grasses and forbs, cattle often avoid areas infested with the exotic species altogether. Goats and sheep, unlike horses and cattle, do not exhibit many of the same maladies after grazing on the plant and have been used in the past by ROMO as a control tactic, though other biological and herbicide methods have proved more effective.[2]

Management Strategies

Leafy spurge is most successfully controlled with integrated pest management (IPM) involving a combination of herbicide treatments and biological controls. IPM methods have been effective in controlling leafy spurge populations in both ROMO and TERO. Because of the longevity of potential germination, persistent treatment needs to be considered for at least eight years after the leafy spurge is first spotted in an area. Herbicide applications of dicamba, picloram, and 2,4-D are the preferred and recommended chemical options. Past applications in ROMO have used picloram. ROMO also released a flea beetle (*Aphthona flava*) in 2001 and 2002 to combat leafy spurge. The larvae of *Aphthona flava* feeds on the roots of leafy spurge, thus stunting growth. As the flea matures it continues to consume the plant, eventually resulting in plant death. A Forest Service study on the efficacy of fire management for controlling leafy spurge concludes that it is not a recommended management process. Fire usually leaves the most destructive portion of the plant- its roots- alive and intact. Treatment methods that included the use of animals, such as the use of goats in ROMO in 1989, are noted in the ROMO Invasive Exotic Plant Management Plan. While the use of goats in Cow Creek to help fight leafy spurge was generally positive, the practice was discontinued when the goats started intruding on bighorn sheep areas. Using competitive grasses is another option for leafy spurge treatment, however, many of the most competitive grasses, such as crested wheatgrass (*Agropyron cristatum*), are nonnative to ROMO. Manual treatments cannot be used on leafy spurge as the biological makeup of the species dictates that when pulled, the roots will retaliate by initiating regrowth of the plant.[3]

Recommendations

It is this author's recommendation that an integrated pest management directive be implemented in ROMO's treatment of leafy spurge. The combination of herbicide spraying as well as the release of additional *Aphthona flava* would be practical given the seasonal nature of ROMO's exotic crew. Once the seasonal crew leaves in the fall and herbicide spraying ceases, the flea could continue combating leafy spurge. The ROMO Invasive Exotic Plant Management Plan indicates that chemical, biological and mechanical options are all approved methods for treatment, though mechanical methods should generally be avoided for reasons mentioned above. Additionally, the Invasive Exotic Plant Management Plan lists leafy spurge as a species with high treatment priority, but according to YER, treatment has dwindled in recent years. Unbroken and persistent treatment is recommended to fully control leafy spurge due to its long period of seed viability.

Table 1. Treatments of leafy spurge in Rocky Mountain National Park with herbicide.

Year End Exotics Report	Treated Leafy Spurge?	Acreage treated with herbicide
2000	No	0 acres
2001	N/A	N/A
2002	N/A	N/A
2003	Yes	15.5 acres
2004	Yes	21 acres
2005	N/A	N/A
2006	Yes	27.3 acres
2007	Yes	3.67 acres
2008	Yes	N/A
2009	Yes	11 acres
2010	No	0 acres
2011	Yes	23 acres
2012	Yes	67 acres
2013	No	0 acres
		Key: N/A = no report available

Endnotes

[1]Gwendolyn Thunhorst and Jil M. Swearingen, "Leafy Spurge," Plant Conservation Alliance's Alien Working Group, http://www.nps.gov/plants/alien/fact/eues1.htm (accessed July 7, 2014); David D. Biesboer and Nancy Eckardt, "Leafy Spurge: Element Stewardship Abstract for *Euphorbia esula*," The Nature Conservancy: Weeds on the Web, http://www.invasive.org/weedcd/pdfs/tncweeds/euphesu.pdf (accessed July 7, 2014); David Kazmer and Ronald W. Marrs, "Assessing Long-term Impact of Leafy Spurge Biological Control Agents: Conclusions from a 6-year study," US Department of Agriculture: Project USDAAPHIS5179 #58-5436-1-221, http://www.team.ars.usda.gov/v2/publications/WyoReport%20Marrs2.pdf (accessed July 8, 2014); Susan Stitt, et al, "Classification of Leafy Spurge with Earth Observing-1 Advanced Land Imager," *Rangeland Ecology & Management* 59, no. 5 (Sep. 2006): 507-511; Northern Prairie Wildlife Research Center, "An Assessment of Exotic Plant Species of Rocky Mountain National Park: *Euphorbia esula* L.," http://www.npwrc.usgs.gov/resource/plants/explant/euphesul.htm (accessed July 7, 2014); Cynthia Pritekel et al, "Impacts from invasive plant species and their control on the plant community and belowground ecosystem at Rocky Mountain National Park, USA." *Applied Soil Ecology* 32, (January 2005): 132–41; Mohammed A. Kalkhan et al., "Assessing exotic plant species invasion and associated soil characteristics: A case study in eastern Rocky Mountain national Park, Colorado, USA using the pixel nested plot design," *Applied Soil Ecology* 35, (September 2007): 622-634; Corey L. Gucker, "*Euphorbia esula*," US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, http://www.fs.fed.us/database/feis/plants/forb/eupesu/all.html#ManagementConsiderations (accessed July 7, 2014); Julie Knudson, Matt Ounsworth, Michael Prowatzke, Jamie Dahlkemper, Jim Bromberg, and Brian Kolokowsky, "Rocky Mountain National Park Exotics Year-End Reports," Rocky Mountain National Park: Division of Resource Stewardship, 2000-2013; Rocky Mountain National Park, "27 Years of Exotic Plant Control in Rocky Mountain National Park: Summary and Recommendations," 1987.

[2]Gwendolyn Thunhorst and Jil M. Swearingen, "Leafy Spurge." Plant Conservation Alliance's Alien Working Group, http://www.nps.gov/plants/alien/fact/eues1.htm (accessed July 7, 2014); Adams County Weed Department, "Leafy spurge," Adams County Extension, http://www.colostate.edu/Dept/CoopExt/Adams/weed/pdf/Leafy_spurge.pdf (accessed July 8, 2014); K.F. Best et al, "The Biology of Canadian Weeds: *Euphorbia esula* L.," *Canadian Journal of Plant Science* 60 (November 1979): 651-663; Richard W. Hanson et al, "Distribution of biological control agents of leafy spurge (*Euphorbia esula* L.) in the United States: 1988-1996," *Biological Control* 10, (July 1997): 129-142; K.G. Beck, "Leafy Spurge: Fact Sheet No. 3.107," Colorado State University Extension: Natural Resource Series, http://www.ext.colostate.edu/pubs/natres/03107.pdf (accessed July 7, 2014); Diane L. Larson et al, "Short-term disruption of a leafy spurge (*Euphorbia esula)* biocontrol program following herbicide application," *Biological Control* 40 (Fall 2007): 1-8; Gale L. Wolters et al, "Herbicide and fire effects on leafy spurge density and seed germination," USDA Forest Service: Rocky Mountain Forest and Range Experiment Station, http://www.lib.ndsu.nodak.edu/repository/bitstream/handle/10365/4134/753WOL94.PDF?sequence=1 (accessed July 7, 2014); Julie Knudson, Matt Ounsworth, Michael Prowatzke, Jamie Dahlkemper, Jim Bromberg, and Brian Kolokowsky, "Rocky Mountain National Park Exotics Year-End Reports," Rocky Mountain National Park: Division of Resource Stewardship, 2000-2013; Corey L.

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[3]Rodney G. Lym and Calvin G. Messersmith, "Cost-Effective Long-Term Leafy Spurge (*Euphorbia esula*) Control with Herbicides," *Weed Technology* 4, no. 3 (Jul.-Sep. 1990): 635-641; Rodney G. Lym and Dwight Tober, "Competitive Grasses for Leafy Spurge (*Euphorbia esula*) Reduction," *Weed Technology* 11, no. 4 (Oct.-Dec. 1997): 787-792; National Park Service, "Integrated Pest Management Manual: Leafy Spurge," NPS Explore Nature: Explore Biology, http://www.nature.nps.gov/biology/ipm/manual/spurge.cfm (accessed July 7, 2014);
National Park Service, "Invasive Exotic Plant Management Plan and Environmental Assessment: Rocky Mountain National Park (2003)," Rocky Mountain National Park. http://www.nps.gov/romo/parkmgmt/upload/exotic_plant_ea_final.pdf (accessed July 7, 2014); Corey L. Gucker, "*Euphorbia esula*," US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, http://www.fs.fed.us/database/feis/plants/forb/eupesu/all.html#ManagementConsiderations (accessed July 7, 2014); Julie Knudson, Matt Ounsworth, Michael Prowatzke, Jamie Dahlkemper, Jim Bromberg, and Brian Kolokowsky, "Rocky Mountain National Park Exotics Year-End Reports," Rocky Mountain National Park: Division of Resource Stewardship, 2000-2013.